Relationship Between Physical and Biological Properties on the Microscale: A Cross-Comparison Between Differing Coastal Domains

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LONG-TERM GOALS

Our long-term goal is to quantify the interactions between small-scale biological and physical processes within the upper ocean.

OBJECTIVES

Attenuation of light and sound propagation in the upper ocean is tightly linked to the patterns of vertical distribution of particulate matter (primarily detritus, phytoplankton, and zooplankton). Local maxima in these distributions frequently occur within the euphotic zone, and are often concentrated within depth intervals that are less than 1-2m thick (e.g., Dekshenieks et al. 2001, Cowles 2004). Of particular interest are the steep vertical gradients of stratification and/or shear that often exist at the boundaries of these thin plankton layers, and which are implicated in their formation and maintenance (e.g., Stacey et al. 2007, Birch et al. 2008). We are extending the analysis of thin plankton layers by examining the microstructure datasets obtained over the past decade by the Ocean Mixing Group at Oregon State University. Tens of thousands of profiles have been obtained over the central Oregon shelf (COAST), over the New Jersey shelf (SW06), and around and through the buoyant Columbia River plume (RISE). Plots of cross-shelf property distributions have revealed extensive layers of

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enhanced particulate biomass. Over the Oregon continental shelf in 2001, successive cross-shelf transects consistently revealed filaments of turbidity that extended O(10km). Chameleon profiles obtained off the Washington coast in 2006 also detected layers of enhanced chlorophyll fluorescence that appeared to occur in vertical intervals of relatively low TKE dissipation. In the original processing, the physical dynamics in and around these turbidity and chlorophyll features were not examined. We are now addressing the explicit relationships between these features.

Our specific objectives address the mechanisms that form and maintain steep gradients and thin layers of particulate concentration. Our objectives are to:

- examine existing datasets of Chameleon profiles (upwelling domain over Oregon shelf, CR plume, NJ shelf) for persistent layers of particulate matter (defined by turbidity or chlorophyll);
- quantify the relationship between layer characteristics (vertical gradients, thickness, relationship to pycnocline) and physical descriptors (stratification, shear, TKE dissipation, turbulent mixing);
- quantify the spatial patterns, temporal persistence and coherence of the physical descriptors to assess how these permit both persistent layers and regions void of thin layers;
- compare these relationships as expressed within the upwelling system, buoyant plume, and NJ shelf;
- relate regional layer characteristics to local and regional forcing (wind, current jets, etc);
- examine results in the context of recent theoretical developments about layer formation and maintenance.

APPROACH

We address the project objectives through a multi-stage analysis of the various datasets obtained with Chameleon. We have sorted the dataset of profiles to obtain those with quality-controlled turbidity or chlorophyll fluorescence data. Then subsets of those data have been examined for temporal and/or spatial coherence of identifiable features, particularly the steepness of vertical gradients and local maxima in turbidity or chlorophyll fluorescence. Since no automated methods exist for this type of feature extraction, we are developing and validating layer-referenced gradient detection methods for the Chameleon datasets. We are examining the relationship between vertical gradients of particles with stratification, shear, and TKE dissipation, using depth (or density) of layer maxima as the reference level for analysis. Given the high quality of the shear probe data from the Chameleon datasets, we can resolve TKE dissipation into 0.5 m depth intervals relative to the plankton layer boundaries. As we progress in the analysis, we will apply multi-dimensional ordination to examine the parameter ranges within which we observe persistent layers of particles, and determine if regional differences exist in these relationships.

WORK COMPLETED

We have focused the initial analysis work on the several thousand Chameleon profiles obtained off the Oregon coast during 2001 and 2006 that display obvious planktonic thin layers. We have found wavelet analysis useful in the data extraction process. Using a feature-referenced approach, we are currently compiling statistics on the relationship between small-scale mixing parameters and plankton features.

RESULTS

We illustrate our results to date with figures that relate plankton layers, as represented by fluorescence, to TKE dissipation (epsilon), stratification (N^2) and density. The data were obtained along a transect just west of the mouth of the Columbia River in May 2006.

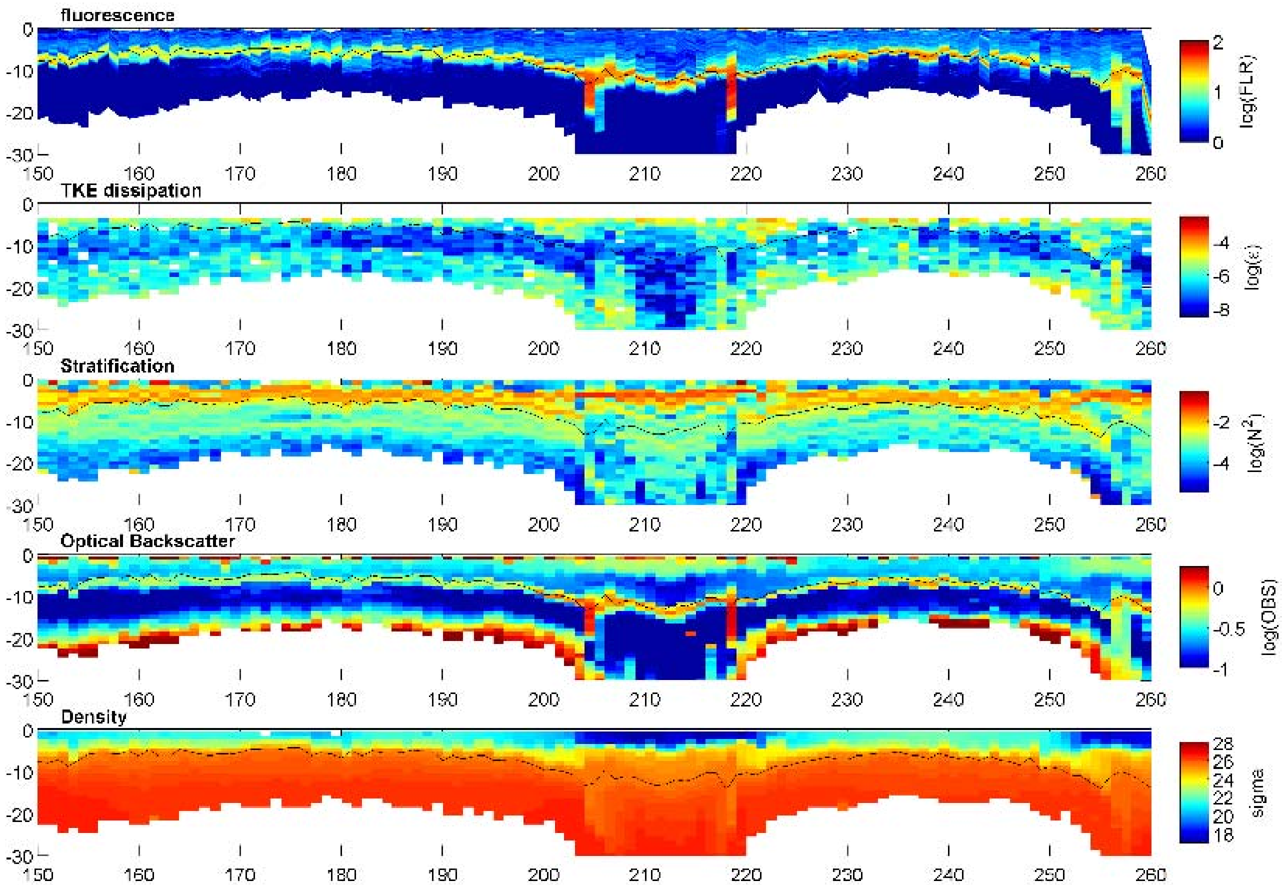

Figure 1. Vertical section across a portion of the Columbia River plume in May 2006, illustrating 110 successive Chameleon profiles during an east-west transit. X-AXIS: profile #; Y-AXIS: depth(m). Ship turned around at profile #211. Upper panel shows the fluorescence layer (log units), with maximum value represented by thin black line. Successive panels show the relationship of that fluorescence maximum with TKE dissipation, buoyancy frequency, optical backscatter, and density.

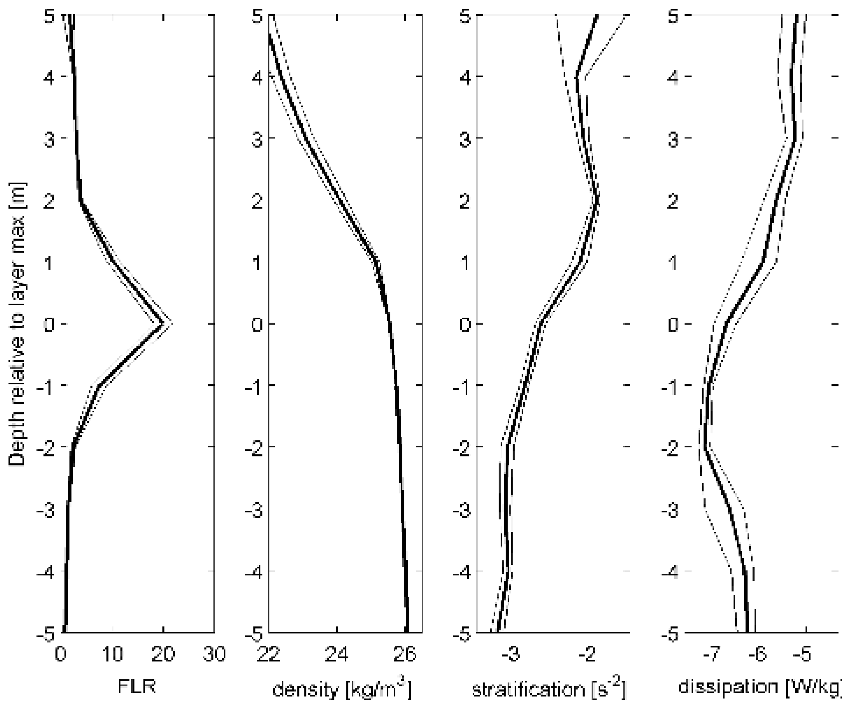

Figure 2. Compilation of feature-referenced statistics of fluorescence, density, stratification and TKE dissipation from the Chameleon transect illustrated in Figure 1.

Our initial results suggest the layer resides in a transitional region below the stratified, turbulent plume of the Columbia River. The plankton layer is capped above by relatively higher stratification, while dissipation and mixing are considerably lower below the layer. We suspect that strain and dissipation play competing roles in layer evolution.

IMPACT/APPLICATION

We expect that this work will reinforce the need for coincident measurements of microstructure physics and biology.

TRANSITIONS

None at this time.

RELATED PROJECTS

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PUBLICATIONS (refereed)

None